STUDY PROJECT

GETTING THE U.S. DEFENSE TECHNOLOGY BASE BACK ON TRACK

BY

Colonel Joseph L. Bergantz
United States Army

USAWC CLASS OF 1992

U.S. ARMY WAR COLLEGE, CARLISLE BARRACKS, PA 17013-5050

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

1a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release. Distribution is unlimited.
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S)	5. MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZATION U.S. Army War College 6b. OFFICE SYMBOL (If applicable)	7a. NAME OF MONITORING ORGANIZATION
6c. ADDRESS (City, State, and ZIP Code) Root Hall, Building 122 Carlisle, PA 17013-5050	7b. ADDRESS (City, State, and ZIP Code)
8a. NAME OF FUNDING/SPONSORING ORGANIZATION 8b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c. ADDRESS (City, State, and ZIP Code)	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO. / PROJECT NO. / TASK NO. / WORK UNIT ACCESSION NO.

11. TITLE (Include Security Classification)

Getting the U.S. Defense Technology Base Back On Track

12. PERSONAL AUTHOR(S)

Colonel Joseph L. Bergantz

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Study Project	FROM ______ TO ______	92/03/01	36

16. SUPPLEMENTARY NOTATION

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

To remain the world leader with a credible military force and to modernize this force within declining defense budgets, the U.S. must develop a viable technology strategy. This strategy should emphasize four major initiatives for restoring American technical superiority: 1) investment strategy optimization; 2) management improvements; 3) personnel recruitment and retention enhancements; and 4) government, industry, and university cooperative efforts. In order to help realize technical dominance, the DOD has identified critical technology areas which will enable significant weapon system advancements. Not only will these critical technologies benefit the DOD, but they will also benefit the commercial sector. This document describes the general background of the current defense technology base, identifies issues confronting this technology base, and recommends solutions to those issues. These recommendations should then be adapted to high-leverage critical technologies in the form of a national technology strategy to exploit the limited assets available.

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT ☐ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT ☐ DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION UNCLASSIFIED
22a. NAME OF RESPONSIBLE INDIVIDUAL Colonel Lorna R. Strzelecki, Project Adviser	22b. TELEPHONE (Include Area Code) 717/245-3477 22c. OFFICE SYMBOL AWCAA

DD Form 1473, JUN 86 Previous editions are obsolete. SECURITY CLASSIFICATION OF THIS PAGE

USAWC MILITARY STUDIES PROGRAM PAPER

GETTING THE U.S. DEFENSE TECHNOLOGY BASE BACK ON TRACK

AN INDIVIDUAL STUDY PROJECT

by

Colonel Joseph L. Bergantz, AV
United States Army

Colonel Lorna R. Strzelecki, ANC
Project Advisor

U.S. Army War College
Carlisle Barracks, Pennsylvania 17013

ABSTRACT

AUTHOR: Joseph L. Bergantz, LTC, USA

TITLE: Getting the U.S. Defense Technology Base Back on Track

FORMAT: Individual Study Project

DATE: 1 Mar 1992 PAGES: 36 (Inclusive of Endnotes/Bibliography) CLASSIFICATION:Unclassified

To remain the world leader with a credible military force and to modernize this force within declining defense budgets, the U.S. must develop a viable technology strategy. This strategy should emphasize four major initiatives for restoring American technical superiority: 1) investment strategy optimization; 2) management improvements; 3) personnel recruitment and retention enhancements; and 4) government, industry, and university cooperative efforts. In order to help realize technical dominance, the DOD has identified critical technology areas which will enable significant weapon system advancements. Not only will these critical technologies benefit the DOD, but they will also benefit the commercial sector. This document describes the general background of the current defense technology base, identifies issues confronting this technology base, and recommends solutions to those issues. These recommendations should then be adapted to high-leverage critical technologies in the form of a national technology strategy to exploit the limited assets available.

INTRODUCTION

In the past, the U.S. has maintained a decided technological edge over her adversaries. Force structure was predominantly based on technologically superior weapon systems facing a numerically superior, but technologically inferior threat. As the 1991 National Security Strategy states, "maintaining this technological margin will become increasingly difficult as access to advanced weaponry spreads and as the defense industry shrinks".[1] It is paramount that the U.S. focus its efforts on high-leverage areas that enhance its advantages and exploit the weaknesses of potential enemies.[2]

These high-leverage areas are enumerated in the 1991 Defense Critical Technologies Plan, in the form of 21 critical technologies. Unfortunately, current trends indicate that the Soviet Union is ahead of the U.S. in pulsed power, and Japan outdistances the U.S. in robotics, photonics, semi-conductor materials, superconductivity, and biotechnology. In addition, the U.S.'s lead in many other critical technology areas is waning.[3]

To reverse these trends, the U.S. must revitalize its technology base. Four major initiatives should be pursued to regain a decisive lead in not only defense, but also commercial technology. First, the U.S. must reevaluate its technology investment strategy to ensure that technology is adequately funded, even in the face of drastically constrained DOD budgets. Second, technology base management organizations need to be created, restructured, or streamlined; thereby, reducing duplication of effort and optimizing national technology base assets. Third, the scientist and engineer community within government civil service must be stimulated to retain quality personnel, as well as attract new talent. Finally, cooperation among the government, industry, and universities must be strengthened to promote governmental and commercial development of technology; to optimize facilities and personnel necessary for specific critical technology research; and to eliminate inefficiencies. This paper will describe the defense technology background, address issues, and suggest recommendations in the context of the four major initiatives.

BACKGROUND

Investment

With the collapse of the Soviet Union, a well-focused threat to U.S. national security no longer exists. As a result, the U.S. is restructuring its military from a threat-based force to a capabilities-based force; downsizing all three services; and reducing forward-deployed forces to those of forward-presence. During these uncertain and changing times, much political pressure exists to cut severely the DOD budget. Consequently, modernization, which includes the defense technology base, will suffer setbacks. A technology base investment strategy must be designed to exploit the assets which remain.

Investments in defense research and development (R&D) occur in three major ways. First, certain R&D efforts are contracted by the Department of Defense (DOD). Second, defense contractors invest corporate profits into in-house R&D projects. And finally, Independent Research and Development (IR&D) is an investment method through which defense contractors can bill a portion of their in-house R&D costs to the government (chargeable as overhead), as a function of doing business, provided certain conditions are met.[4]

IR&D, along with the other two methods, is essential to the nation's security, since independent research and development supports our nation's ability to compete technologically. Over the years, one of the key ingredients of the investment strategy has been the IR&D process. Overhauling this process, to stimulate greater commercial and government investment, is a major step in regaining lost technological superiority.

The term "independent" is important since each company has the freedom to choose what areas to research. However, one major restriction imposed is that the R&D must show potential military relevance.[5] In addition, Congress further restricts the process by capping the funds which defense contractors can recoup. Even though this limitation is adjusted periodically to reflect inflation, the contractor seldom, if ever, recovers the entire limit.[6] This is true because the government determines how much of the cost is allowable (e.g. in 1989, government-allowed IR&D totalled $2.2B).[7] The remainder of the firm's IR&D costs (unrecovered) are funded by the company itself, in hope of later payoffs.[8]

Of the three methods for defense R&D investment described, IR&D is probably the most advantageous to the government. It holds that middle ground between the extremes of DOD-contracted R&D and solely company-funded R&D. IR&D also ensures that the government retains limited control, and it affords industry more of a free rein.

Several major benefits are attributable to the IR&D process. IR&D allows company scientists and engineers to explore and to develop imaginative concepts for DOD without severely inhibitive government restrictions. IR&D enhances the commercial technological community and reduces developmental risks of advanced systems. Many examples exist where key U.S. weapon technologies were developed that did not originate as a military requirement or from contracted funding. Some examples include: critical technology related to the development of the Redeye and Stinger air defense missiles; the submarine-launched, Tomahawk cruise missile; and the F-16 fighter.[9]

Additionally, recent spending figures show that roughly one quarter of all defense science and technology base activities are funded through IR&D.[10] A recent analysis of the FY92-93 Defense Budget Request indicates that, while direct-funded R&D will remain constant, IR&D will suffer setbacks. This occurs since IR&D, as well as company in-house efforts, is closely attached to procurement accounts, which are bearing the brunt of modernization cuts.[11]

Management

The management of the defense technology base is quite diverse. As a result of the Goldwater-Nichols Act, the technology base management structure has been reorganized (see figure one).[12] This legislation created the Under Secretary of Defense for Acquisition, USD(A), also known as the Defense Acquisition Executive, and recreated the Director

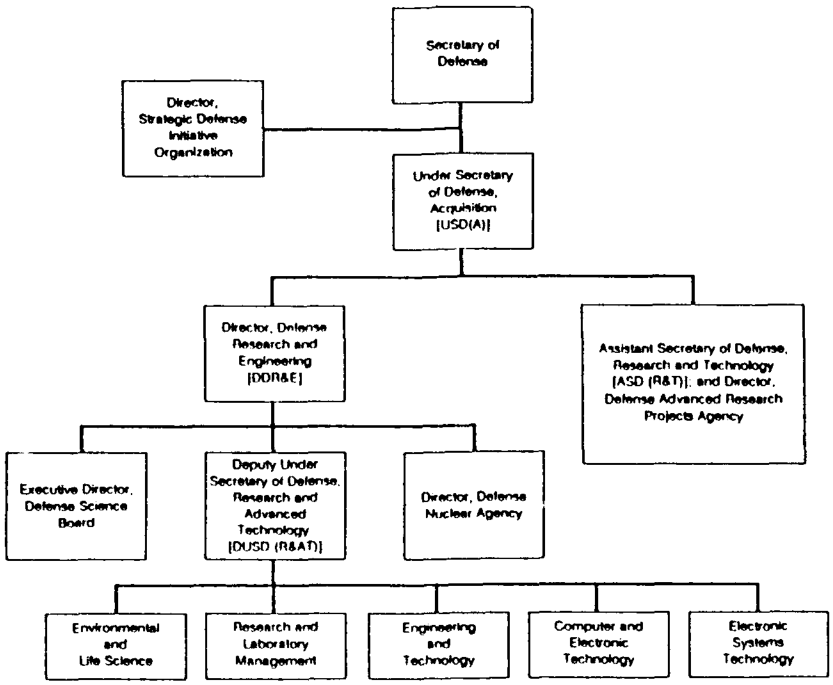

Figure 1. Management of the DOD Technology Base Program

of Defense Research and Engineering (DDR&E), but with less responsibility.[13]

The primary function of the USD(A) is to oversee and approve procurement of the Service's major weapon systems and R&D in DOD's technology base programs, with the exception of the Strategic Defense Initiative (SDI). On the other hand, the DDR&E is responsible for oversight of only R&D activities for the Services and the Defense Nuclear Agency (DNA). The separation between the two organizations is intentional to preclude faulty weapon systems from leaving the laboratory and proceeding forward to the factory.[14]

Two other major organizations exist at DOD-level which deal with the technology base: the Defense Advanced Research Projects Agency (DARPA) and the Strategic Defense Initiative Organization (SDIO). DARPA, as Congress' Office of Technology Assessment (OTA) points out, acts as DOD's corporate research organization, capable of working at the "cutting edge" of technology.[15] Most of DARPA's projects, contracted through the Services, are with industry, universities, non-profit organizations, and government laboratories.[16] In 1988, DARPA's budget was just under $800M, which is greater than the other defense agencies technology base budgets combined.[17] Although DARPA reports to the USD(A), the SDIO reports directly to the Defense Secretary, which prevents the USD(A) from managing SDI activities.[18]

SDIO is a centrally-managed organization with five technical program directorates. SDIO is almost equally divided between basic R&D and the acquisition program Global Protection Against Limited Strikes (GPALS). In 1991, SDIO funded critical technologies in the amount of $651M or approximately 23% of its annual budget.[19]

Below the DOD-level, technology base organizations include the various laboratories operating under the direction and guidance of each Service. Each Service manages its technology base programs differently. The Army is more decentralized; the Navy performs 60% of its technology base efforts in-house; and the Air Force contracts out most of its programs.[20]

The final noteworthy science and technology organization is the newly-created Critical Technology Institute (CTI). The CTI is a product of the 1991 Defense Authorization Act. Originally, the CTI would have been subordinate to the President's Office of Science and Technology Policy (OSTP). Recently, CTI's sponsorship has been changed. Its purpose, coordinating federal government critical technology efforts, remains the same.[21]

In summary, the OTA notes that "the majority of the technology base program is conducted by industry (50%), with universities performing 20%, and the DOD in-house laboratories conducting the remaining 30% of effort".[22] DOD's complex technology base is planned, organized, and implemented by DARPA, SDIO, and the three Services, with oversight and guidance provided by the Office of the Secretary of Defense (OSD). Nonetheless, it appears that the

CTI will play a large role in the future.

Personnel

Many of the problems associated with defense technology are in its personnel base. Some of the shortcomings have already been addressed within recent Defense Management Reviews (DMR). As the OTA has observed, "ultimately, a vibrant domestic technology base depends on a steady supply of highly capable scientists and engineers".[23]

Although there is an increasing demand for scientists and engineers in technical fields, such as, avionics, computer software, and electrical systems, current trends indicate a shortage of U.S. trained professionals in DOD. Some of these shortages have been satisfied by foreign nationals, not by U.S. citizens.[24]

Foreign nationals are not only involved throughout DOD, but are also enrolled in PhD programs throughout America. Roughly two-thirds of these talented personnel remain in the U.S. after degree completion. Nevertheless, many go home; and their talents are lost to foreign competitors.[25]

Shortages are also increasing in industry which typically pays much higher salaries. A 1989 Aerospace Industries Association of America survey indicated aerospace companies had significant scientist and engineer shortages in certain areas. Furthermore, 85% of the companies surveyed predicted recruitment difficulties in the future.[26]

Many of these shortages reflect a trend within the U.S. education system. As Dr. Allen Bromley, the President's scientific advisor, has stated, one of the President's three major research and development initiatives for FY92 is education and human resources.[27] And yet elementary schools are failing to encourage young students to enter science and technology fields.

Education should not be limited to scientists and engineers, but applied to the entire work force. Indeed, an educated labor pool is essential for U.S. industry to remain competitive. For this reason, many industrial in-house education programs already exist, ranging from remedial and on-the-job training to advanced-level courses.[28]

Government/Industry/University Cooperation

Many efforts to increase cooperation among DOD agencies, industry, and universities already exist. For example, the University Research Initiative (URI), sponsored by DOD, funds multidisciplinary research contracts designed to enhance efforts between universities, industry, and DOD laboratories. URI also subsidizes human resource development through fellowships, post doctoral investigations, and scientific exchange programs to promote interaction between DOD laboratories and universities.[29]

Another initiative designed to break down barriers is the Engineering Research Centers concept. These centers concentrate on specific technologies, such as biotechnology or robotics, and involve representatives of industry, government, and universities in the establishment of long term engineering research. These centers also have international elements which promote international collaboration with foreign corporations.[30]

As one can see, there are many internal and external factors which DOD can influence in order to improve the climate of the defense technology base. One can also imagine that this environment is fraught with problems. Let us now consider specific issues associated with each of the four major initiatives.

ISSUES

Investment

There are many issues associated with funding a viable technology base. For example, front-end R&D investment has declined significantly since the 1960's. Indeed, the cumulative shortfall from the funding peak in the mid 1960's now amounts to roughly $25B which equates to some 250,000 technical man years that were not worked.[31]

Another fundamental issue is a lack of funding stability for R&D, specifically for research. Typical fluctuations, of more than 10% per year, frustrate planning, undermine innovation, and work against long term strategies.[32]

Many deficiencies also exist with the IR&D process. Of significant concern is the control of IR&D efforts. The DOD supports industry's concerns over maintaining latitude for innovation, even though the Services want greater control over how their money is spent. A second and more bothersome concern is that IR&D incentives are oriented toward short term applications (which quickly demonstrate relevance and recover cost) instead of long term technology.[33]

A major reason for the recent lack of enthusiasm for IR&D is that Bid and Proposal (B&P) costs are linked to IR&D under the Federal Acquisition Regulations (FARs). As a result, companies recover investments in both areas through their overhead pool on defense contracts. With the increased emphasis from government on competition, auditing, and more extensive negotiations, B&P costs have escalated significantly. Since both IR&D and B&P costs are capped by Congress and are inextricably linked in the same overhead pool, IR&D has ultimately suffered.[34]

Furthermore, many claim IR&D is overregulated:

> One software firm has had a year full of audits. The firm estimates that the government has spent $300K to audit a $500K overhead. Another small aerospace company decided not to sell products to the DOD due to the hassle it gets from government visitors and the extensive paperwork.[35]

This situation causes profit losses and adversely affects R&D investment. Such overregulation also manifests itself in Congressional limitations, which preclude defense contractors from fully recovering their IR&D costs and investments.

Management

The 1986 Packard Commission report and subsequent legislation have done much to eliminate management problems. Not only have program managers been given back more time for actual management activities, but also all acquisition regulations and directives are being reviewed and revised to eliminate duplication and overly burdensome requirements. Yet, there are numerous other management problem areas still to be addressed.

Just as with the investment strategy, the managerial environment also tends to be short-sighted. Therefore, multi-year procurements and, even more fundamentally, multi-year defense budgets must be considered seriously.

Still another issue requiring attention is further centralization of the defense technology base. Both research centers and labs will suffer management cutbacks over the next five years. Therefore, Congress, through the Defense Authorization Act of 1991, has directed the DOD to report back on a consolidation and conversion plan for defense R&D labs.[36] This plan should address consolidation of critical technologies under some form of central management.

Currently, there is no central focus for technology base planning and control throughout DOD. The OSD oversees Service technology base programs at one organizational level, DARPA at a second, and SDIO at the highest. This structure inhibits coordination and leads to the lack of a high level advocate for critical technology programs. Such a structure also leads to wasteful duplication, lack of unity of effort to solve common problems, piece-meal taskings, and inattention to areas that are on no component organization's agenda.[37] Hopefully, the CTI will solve these problems.

Even Total Quality Management (TQM), which the DOD has embraced, argues for continuous improvement of all processes within an organization (e.g. elimination of unnecessary management levels) and favors centralization.[38] TQM also requires a willingness to change and a long-term commitment.[39] Therefore, to ultimately make TQM work, all management levels must accept its tenets and be willing to wait for results. One of the greatest challenges, facing managers over the next few years, will be pursuing TQM to its fullest in a system that is geared toward short term results and annual budgets and contracts.

Another major concern facing the defense technology base management structure is the reluctance to take high risks to achieve high payoffs.[40] Such high risks must be taken, even when faced with tighter budgets. One can argue, that only through high risk/high payoff successes, can the U.S. protect its military superiority, while numbers of weapons are diminishing.

A closely related problem is the inability to quickly field successful high-leverage advanced technology efforts. An acquisition fast track of some sort is sorely needed.[41] Such an innovative approach would mean fielding equipment that is state-of-the-art and not two or three generations out of date. In the future, such an approach may take the form of technology insertion into existing systems, rather than an application to new procurement programs.

Many persistent problems remain in the management of technology. The majority of these problems are closely linked to the personnel involved in the defense technology base.

Personnel

One of the major personnel concerns, according to the Working Group on Technology, is the inability to attract critical technology-skilled employees to government positions. Competent people for these positions exist in industry; however, government salaries cannot compete with counterpart salaries in industry. Furthermore, current conflict-of-interest rules discourage individuals from entering government service.[42]

Another concern is the low rate at which U.S. citizens become scientists and engineers. Greater emphasis on science and engineering, during the early years of a student's education, is needed. Current trends indicate a decline of almost 25% in the number of young people enrolling in math and science programs in college over the next ten years.[43]

To counter these trends, industry is independently providing funds both to schools and students from kindergarten through the university level. The aerospace industry's Global Perspective reports, "beginning at the elementary level, companies provide tutoring, plant tours, career day speakers, academic competitions, equipment, summer jobs, and assistance in developing curricula".[44]

The lack of upward mobility and job satisfaction are two more concerns within the defense technology community. For example, under the current government civil service grade structure, most personnel top out at grade level GM-15. This phenomenon occurs because the only way to progress beyond GM-15 is through Senior Executive Service (SES) grades or super-grade GS levels, which are few and far between. To attract and retain superior technology base personnel, a revision of the grades and pay structure is necessary.

In the area of job satisfaction, a major weakness is the lack of continuing education. Since critical technologies will lead to big payoffs, it is essential that managers be adequately schooled in these technologies. Many government managers do not feel well-trained since they have not received recent schooling or recurrent training. Keeping the government work force technically refreshed and competent, in a rapidly changing environment, is a major objective for the future.[45]

Government/Industry/University Cooperation

The aerospace industry has identified the lack of cooperation between government and industry as a major obstacle in formulating a coherent critical technology strategy.[46] Industry has formed the National Center for Advanced Technologies (NCAT) to overcome this obstacle. This organization has spearheaded efforts to develop "roadmaps" for each critical aerospace technology. These roadmaps concentrate on the elements of each technology, identifying the necessary capabilities and techniques.[47]

Much needed groundwork is being laid to overcome the lack of cooperation. But, what has caused this lack of cooperation between government and industry?

A major contributor to this situation is the Competition in Contracting Act (CICA). CICA sounds great on paper; however, many of the by-products of CICA are unhealthy. For example, CICA has encouraged competition solely for competition's sake. It has encouraged many unqualified firms to "buy in" at the expense of quality procedures. In addition, CICA has fostered competition through dual-sourcing which has decreased industry's willingness to invest in new technology that the government will then transfer to a competitor. Furthermore, mandatory competition has split production between competitors which increases unit cost. Finally, CICA has inhibited the development of long-term relationships between prime contractors and subcontractors which works against TQM techniques.[48] All of these factors have actually had a negative effect on the defense technology base. Although competition has been encouraged, cooperation has been stifled.

The other corner of this cooperation triangle focuses on the universities. Here again, many cooperative efforts are on-going. Nevertheless, much more progress is needed. For example, curricula are lacking which could educate scientific and engineering personnel in critical technologies.

Furthermore, many problems exist in providing equal opportunity within universities to minorities and women. Limited on-going efforts exist to encourage minorities and women to pursue general technological careers.[49] However, much more emphasis is required, particularly in the critical and enabling technology fields.

Another frequent complaint is that the lack of cooperation between industry and universities has contributed to the decline of innovativeness of U.S. industry and international competitiveness. As a result, the government is becoming far more directive with research funds. For example, some federal agencies, like the National Science Foundation, are using funds to encourage industry and university cooperation. In addition, many state governments have launched cooperative research efforts.[50]

RECOMMENDATIONS

Investment Strategy

A pervasive problem, which has yet to be resolved, is industry's philosophy of investing primarily in the short term, and its reluctance to take a long term approach. It appears that corporate management consciously makes such decisions purely from a profit motive. As the President's science advisor, Dr. D. Allen Bromley, recently stated, "the return on federal investment in academic, basic research alone is 28% per year"[51]. Thus, industry must begin to understand that IR&D is a good investment; and by foregoing smaller profits in the short term, greater profits can be achieved in the long term. U.S. industry's short-sightedness may be safe for an individual company, but it dilutes the effectiveness of the total U.S. R&D effort when compared to competitors in foreign nations.[52] A reasonable alternative for industry and government would be to channel more efforts into the dual-use technology areas which are applicable to both establishments (an enticement to invest).

Probably the greatest threat to the defense technology base is posed by Japan. Japanese private industry funds a greater share of R&D than does American private industry (65% versus 50%)[53]. Since IR&D is a real bargain for the government (industry spends $2 for every $1 the government pays) and benefits industry as well through commercial applications, the IR&D process should be nurtured.[54]

Industry is not the only one guilty of a short term outlook. The government is also culpable in this regard. Over the years, the DOD investment curve in science and technology looks like a roller coaster. What is required is a long term, stable, investment commitment at increased levels.

The defense planning, programming, and budgeting cycle should be reoriented toward more multi-year projects. Not only could this save money, but it could also stabilize schedules, permit capacity planning, and strengthen the supplier base. An even more fundamental change could entail having Congress review the DOD budget on other than an annual basis. Even though the budget is currently labeled biennial, it still undergoes Congressional review and change annually. Although this recommendation is probably too radical to receive serious support, more moderate fixes, which the Congress could support, should be pursued.

For example, the FARs could be relaxed, along with government interference, in the form of audits, paperwork, and inspections. Such measures, to include the elimination of annual limits on the total defense IR&D and B&P costs, could certainly stimulate industry investment of corporate profits and participation in IR&D programs.[56] Although the recent 1991 Defense Authorization Act has relaxed the term "potential military relevance" to that of "potential interest" to DOD, and advanced agreement thresholds have been increased again; full recovery of IR&D investments by industry is still not allowed.[57]

In addition, delinking IR&D from B&P costs should be accomplished. This could prevent IR&D from being short-changed because of the increased emphasis on the B&P process.

It appears that such radical changes are needed.

Maybe the best solution is to restructure the IR&D process by breaking out IR&D funding as a separate budget line item for each service. This scheme must be well-thought-out to obtain the right mix of defense contractor latitude versus government control.

Other incentives are needed to spawn private R&D investment. For example, investment has been energized somewhat by making the R&D tax credit a permanent incentive. Previously, companies could not count on the credit being available to them from one year to the next.[58]

Depreciation, another incentive, should be revised:

> Depreciation of R&D facilities and equipment should be accelerated from five to three years. The current depreciation schedule provides no real incentive to R&D as technology development speeds up and product cycles get shorter. In semiconductor technology, for example, the product cycle is about two and a half years.[59]

Also, manufacturing investment programs, such as the DOD Industrial Modernization Incentives Program (IMIP), should be strengthened. This program allows the Services to share the costs of modernization with contractors. Productivity improvements (150% better machine utilization, 90% less scrap and rework) more than justify such programs since savings can be reinvested into the R&D base. However, funding levels for these programs are low, less than 1% of the DOD procurement budget.[60]

Congress has also directed the Defense, Commerce, and Energy Departments to develop a National Defense

Manufacturing Technology Plan. Unfortunately, initial funding for this effort is severely restricted.[61] Further support of this effort is needed as well to spur the industrial base and strengthen private investment.

Perhaps the most effective incentive for investment would be ensuring availability of affordable capital. The high cost of capital has increased the debt burden for defense contractors and decreased profitability. The aerospace industry's Global Perspective states that within the present system of long recovery periods, manufacturers have no assurance of ever recovering costs because of high interest rates on loans.[62]

A final consideration is the DOD's latest acquisition policy which reflects increased R&D efforts while procurement programs are reduced or eliminated. Normally, procurement programs would follow the R&D phase. The new philosophy seldom, if ever, will guarantee such follow-on contracts. This philosophy appears plagued with problems. It will be difficult to generate industry enthusiasm for R&D programs which promise no end products in quantity.

The industry paradigm of recovering lost R&D profits through large production contracts will have to be broken. No doubt the end result will be increased R&D costs that will contradict the movement toward declining budgets. Some middle ground must be found that allows limited production of new end-items (enough for a user unit to wring out operationally), somewhere between equipping many units and building only one prototype.

Only through the implementation of such recommendations and hard work with industry can the U.S. establish an investment climate that supports not only a strong technology base, but also a healthy industrial base.

Management

A commitment to productivity enhancing disciplines such as Total Quality Management (TQM) is as important as technology investment. TQM principles should be incorporated wholeheartedly in the defense technology base. By willingly accepting TQM in the research and development of high-leverage technologies, appreciable progress can be realized. Nonetheless, a change of mindset will be required by management personnel. In other words, a more long term approach must be embraced and implemented. Not only should managers be willing to conduct longer term research, but they also must allow and accept failures and take higher risks, which, if successful, will lead to leap-ahead advancements.

One of the ways to reduce risk is to conduct Advanced Technology Transition Demonstrations (ATTDs).[63] The Army technology base has already incorporated ATTDs into its technology strategy. Such demonstrations speed the maturing of advanced technologies in addition to other benefits shown in figure two.[64] One or more ATTDs should be devoted to each of the DOD critical technologies.

- ATTDs provide an opportunity to prove feasibility
- ATTDs provide a team building environment with collaboration by the researchers, developers, the industrial performer, and the operator
- ATTDs provide an opportunity for requirement writers to try new technologies with less risk
- ATTDs should be selected and managed in a less rigid and more streamlined manner than current DoD prototyping projects
- ATTDs are a logical expression of the Packard Commission recommendations on prototyping

Figure 2. ATTD Management Principles

Another significant improvement for management is the consolidation and conversion of defense labs and R&D centers. Based on a recent report to Congress, initiatives will soon be implemented to consolidate or convert selected defense labs and R&D centers.[65] Ideally, the new lab and R&D center structure could be geared to high-leverage technologies. A certain lab could become a world-class developer of a specific critical technology. All the talent, within government ranks, concerning that technology, could be centralized at that facility. Centralization, in this context, could produce substantial savings and efficiencies.

The CTI, another effort for centralization, has been created to focus attention on critical technology management. The purpose of the CTI remains: 1) survey views of industry and universities; 2) identify near, mid, and long term objectives and develop strategies; 3) publish necessary reports; and 4) provide technical support and assistance for policy formulation.[66]

However, the FY92 Defense Authorization Act has changed the composition and emphasis of the CTI. The board of trustees, 21 members, has been reduced to an operating committee of eleven members. Sponsorship has shifted from the OSTP to the National Science Foundation, and no additional funding for FY92-93 has been authorized. Finally, the most important change is the elimination of the ten industry and academia members from the operating committee.[67]

To be successful, the CTI must coordinate critical technologies between DOD and other departments, such as Energy and Commerce. The CTI should also coordinate closely with industry organizations, such as the aerospace industry's National Center for Advanced Technologies (NCAT). This coordination would have been greatly facilitated through direct industrial and academic participation in the CTI, as first proposed. The membership of the operating committee should therefore include industrial and academic representatives. The CTI must also be credibly funded and given some sort of budgetary approval authority; or else its decisions will fall on deaf ears.

Personnel

The DOD has taken some significant steps toward improving the personnel situation in the technology base. First, the 1991 Defense Authorization Act provides grants to students in programs critical to DOD in science and engineering.[68] Many of these grants require the recipient to be a U.S. citizen. This citizenship requirement is designed to foster U.S. participation in critical technology fields.

A second on-going effort is that of education partnerships in which each lab enters into one-on-one partnership agreements with universities in the science, mathematics, and engineering areas.[69] A related program is the work education program where lab directors enlist students and pay them GS-9 salaries, including travel and fees.[70] These students often work for the government during the summer or in lieu of a semester in the normal academic year. Both of these programs are steps in the right direction, but must be expanded to capture a larger group.

Efforts now exist within Congress to upgrade critical management positions. Such rule changes are necessary to improve not only recruiting, but also retention efforts. The only way to lure top talent to the government is to allow competitive salaries and grant higher grade structures. In conjunction with this change, conflict-of-interest rules must be eased or eliminated. Such rule changes could encourage top-of-the-line industry talent to enter government service without fear of conflict-of-interest penalties should they decide to leave government service at a later date.[71]

The Department of the Navy has run a pilot program at China Lake which provides higher salaries for scientists and engineers. A recent Defense Science Board study supports this compensation approach.[72] DOD should press Congress to relieve existing limitations on scientific and technical careerists positions and authorize career incentive pay for top critical technology positions. Lab consolidation should generate needed funds to support this effort.

One fundamental accomplishment of the 1991 Defense Authorization Act is the creation of a directorship for acquisition education, training, and career development within the office of the USD(A),[73] to include parallel directors within each Service. This director can influence both continuing and initial education. Continuing education is important since technology advances so quickly.

Similarly, the government should increase support of initial education and expand outreach programs. For example, government labs could establish a math and science homework hotline for high school students who need assistance. Also, labs and R&D centers could: sponsor open houses for elementary schools and science projects and awards for high schools; provide career counseling for graduating high school seniors; and provide "hands-on" opportunities for students to discover their engineering niche. Such good will efforts can be relatively inexpensive and well worth the time and personnel investment.

Government/Industry/University Cooperation

As noted earlier, the CICA has caused serious problems within DOD. Therefore, substantial changes should be made. For instance, "full and open competition" should be replaced by "effective competition". This change in terminology reflects the government's use of a best value approach rather than lowest bid. Furthermore, competition should be limited to preselected qualified producers who have performed well in the past or can meet clear rules for newcomers. Finally, CICA should be interpreted to encourage long term, predictable relationships between prime contractors and suppliers.[74] These measures could inspire cooperation.

Perhaps the ideal method to stimulate cooperation among all three participants - government, industry, and universities - is to establish Centers of Excellence for each of the key technologies. These centers could operate much like the existing centers do within the Army. The Army currently has Centers of Excellence in five major areas: electronics; rotorcraft; mathematics; optics; and artificial intelligence which are university-based and team Army researchers with civilians from one or more universities.[75] The new Centers of Excellence should focus on industry participation. This concept could benefit the government; but more importantly, it could benefit industry (by allowing technology to be spun-off to commercial applications) and universities (by establishing curricula, which do not now exist, for critical technologies).

Domestic cooperation among industry has improved. Recent winners of major weapon system contracts, have formed industry teams to lower individual investment costs and reduce risk. "To some extent, this will also protect critical U.S. technology," as pointed out in the aerospace industry's Global Perspective.[76]

New legislation has also provided for a "mentor-protege" program. This program provides incentives to large companies, who are DOD contractors, to assist small disadvantaged businesses to become qualified subcontractors and suppliers.[77] While much energy is being devoted to stimulate cooperation among industry domestically, international efforts must be made at the same time.

To foster international cooperation, the government can remove barriers to trade, establish pro-trade policies, and implement technology export policies that make national security and market sense.[78] For example, the government could eliminate technology barriers, such as overly restrictive standards; reform U.S. product liability laws; improve multi-lateral offset understandings; and provide a single DOD policy on defense exports, technology transfer, the industrial base, and arms cooperation.[79]

One last noteworthy initiative is "dual-use" technology, which has both civil and defense applications. In the past, the military establishment often drove technology, and consequently many civil applications or spin-offs came from government-funded technology. Today, the most advanced communications, electronics, and information technology is found in the commercial world. Many of the current and future weapon systems are derivatives of commercial products or spin-ons. Therefore, the distinction between military and civil use technology is blurred, and declining defense budgets will promote this trend. It is in the best interests of government and industry to cooperate on technology advancements through spin-offs and spin-ons.

CONCLUSIONS

In the preceding paragraphs, issues and recommendations were discussed in the context of the four defense technology base initiatives for improvement. Two profound problems are rooted in each of these four initiatives.

First, the philosophy of short-sightedness pervades the entire technology base. Any progress, in changing America's mindset to that of a longer term perspective, will definitely pay big dividends.

Second, control over the defense technology base is sorely lacking. In this regard, the creation of the CTI and the director for acquisition education, training, and career development are both necessary measures to properly focus overall DOD technology base efforts and to come to grips with a well-structured strategy. Since the DOD, universities, and industry are so tightly linked within the technology base, successful policies at the national level must be jointly forged. The recent elimination of direct industrial and academic participation in the CTI is a major setback.

Throughout the defense technology base, the U.S.'s eroding lead is becoming more and more noticeable. This decline is not necessarily confined to the military establishment, but applies to the U.S. economy as a whole. As Donald Snow recently observed:

> Most people, for instance, would add economic well-being or prosperity to their definition of what makes them feel secure. The ability to remain competitive may well be defined increasingly in high-tech terms, and the failure to compete will impose heavy economic, social, and security costs.[81]

In order to stem this tide and put the U.S. defense technology base back on track logical, positive measures must be adopted by both government and industry. The four initiatives should provide the basis for a revitalized technology strategy.

Thus far, DOD is maintaining R&D investments, while reducing or eliminating procurement funding. Time will tell the success of such an acquisition policy. This policy will certainly change the current defense industry. Indeed, further impacts, such as the loss of the national defense production capacity and workforce, greater reliance on commercial sources of equipment, and reduced opportunities to offer U.S. weapon systems for export, will be forthcoming.[82]

Nevertheless, the current political mood is to cut defense indiscriminately. In such uncertain times, the defense technology base must be stabilized and strengthened. The future of not only the defense technology base, but also the U.S. economy, hinges on the actions taken now. One might ask, in these times of constrained resources, can we afford to do this? A more appropriate question would be, **Can we afford not to**?

ENDNOTES

1. National Security Strategy, (Washington, D.C., Government Printing Office, August 1991), p. 30.

2. Ibid.

3. 1991 Joint Military Net Assessment (JMNA), (Washington, D.C., Government Printing Office, March 1991), p. 5-3.

4. U.S. Congress Office of Technology Assessment, Redesigning Defense: Planning the Transition to the Future U.S. Industrial Base, (Washington, D.C., Government Printing Office, July 1991), p. 52.

5. LCDR Joseph Endres and Dr. James Fremgen, "Non-Mandatory Advanced Agreements", Program Manager, (Nov-Dec 1990), p. 24.

6. Ibid.

7. U.S. Congress OTA, Redesigning Defense, p. 50.

8. U.S. Congress Office of Technology Assessment, Defense Technology Base: Introduction and Overview, (Washington, D.C., Government Printing Office, March 1988), p. 17.

9. Glenn W. Goodman, Jr., "Independent R&D Efforts Suffer in DOD's More Competitive Contract Environment", Armed Forces Journal International, (June 1987), p. 102.

10. U.S. Congress OTA, Defense Tech Base, p. 47.

11. U.S. Congress OTA, Redesigning Defense, p. 4.

12. U.S. Congress OTA, Defense Tech Base, p. 62.

13. Ibid., p. 61.

14. Ibid.

15. Ibid., p. 80.

16. Ibid., pp. 80-81.

17. Ibid., p. 80.

18. Ibid., p. 81.

19. LTC Peter Rustin, SDIO, interviewed by LTC Joseph Bergantz (Pentagon, Washington, D.C.), 10 A.M., Nov. 8, 1991.

20. U.S. Congress OTA, Defense Tech Base, pp. 82-83.

21. "1991 Defense Authorization Act", *Public Law 101-510*, (St. Paul, MN, West Publishing Co., 1991), Title VIII, Sec 822.

22. U.S. Congress OTA, *Defense Technology Base*, p. 82.

23. *Ibid*., p. 18.

24. *Ibid*., p. 51.

25. *Ibid*., p. 18.

26. Virginia C. Lopez and David H. Vadas, *The U.S. Aerospace Industry in the 1990s A Global Perspective* (Washington, D.C., Aerospace Industries Association of America, 1991), p. 125.

27. "Can America Maintain Its Edge", *American Legion Magazine*, (August 1991), p. 55.

28. *Global Perspective*, p. 125.

29. U.S. Congress OTA, *Defense Technology Base*, p. 59.

30. Robert W. Rycroft, "Foreign Policy Aspect of Intergovernmental Science and Technology", *Technology in Society*, 12, 2, (1990), pp. 221-222.

31. *Technology for National Security (TFNS)*, (Washington, D.C., Government Printing Office, Oct, 1988), p. 18.

32. *Ibid*., p. 21.

33. U.S. Congress OTA, *Defense Technology Base*, p. 18.

34. J. Richard Iverson, "Subtle Forces Undermine National R&D", *Armed Forces Journal International*, (June 1987), p. 100.

35. *Ibid*.

36. *Public Law 101-510*, Title II, Sec. 246.

37. U.S. Congress Office of Technology Assessment, *Holding the Edge*, (Washington, D.C., Government Printing Office, 1990), p. 8.

38. *Total Quality Management Continuous Improvement Guide*, (St. Louis, MO, U.S. Army AVSCOM Printing Plant, Oct 1990), p. 10.

39. "Give TQM Its Due Respect", *Aviation Week & Space Technology*, (Dec 9, 1991), p. 7.

40. *TFNS*, p. 54.

41. Ibid., pp. 54-55.

42. Ibid., p. 63.

43. U.S. Congress OTA, Defense Tech Base, p. 51.

44. Global Perspective, p. 125.

45. Army Tech Base Master Plan (ATBMP), (Washington, D.C., U.S. Government Printing Office, Nov 1990), Vol. I, p. I-23.

46. Global Perspective, p. 14.

47. Ibid., p. 103.

48. U.S. Congress OTA, Defense Tech Base, p. 70.

49. ATBMP, p. VII-18.

50. Teresa R. Gidley, Dennis O. Gray, and William A. Hetzner, "Cooperative Research and Rising Expectations", Technology in Society, 11 (1989), p. 336.

51. "Can America Maintain Its Edge", p. 29.

52. Murray Weidenbaum, "A Note on R&D Changing National Priorities", Technology in Society, 11 (1989), p. 333.

53. Don Flamm, "U.S Aerospace Industry and Key Technologies for the Year 2000", Asian Defense Journal, (March 1991), p. 76.

54. Kent M. Black, "IR&D, An Essential Element of National Defense", National Defense, (April 1988), p. 37.

55. Global Perspective, p. 124.

56. Ibid., p. 37.

57. PL 101-510, Title VIII, Sec 824., Subsec 2372.

58. Global Perspective, p. 120.

59. Ibid.

60. Ibid., p. 121.

61. PL 101-510, Title VIII, Sec 823.

62. Global Perspective, p. 122.

63. ATBMP, I-9.

64. Ibid., p. I-11.

65. PL 101-510, Title II, Sec 247.

66. Ibid., Title VIII, Sec 822.

67. "1992 Defense Authorization Act", Public Law 102-190, (St. Paul, MN, West Publishing Company, 1992), Title VIII, Section 823.

68. Public Law 101-510, Title II, Sec 247.

69. Ibid., Subsec 2194.

70. Ibid., Subsec 2195.

71. TFNS, p. 63.

72. TFNS, p. 64.

73. PL 101-510, Title XII, Sec 1202, Subsec 1703.

74. U.S. Congress OTA, Redesigning, p. 71.

75. ATBMP, p. VII-12.

76. Global Perspective, p. 9.

77. PL 101-510, Title VIII, Sec 831.

78. Global Perspective, pp. 17-18.

79. Ibid.

80. Ibid., pp. 94-95.

81. Donald M. Snow, "High Technology and National Security: A Preliminary Assessment", Armed Forces and Society, 17, 2 (Winter 1991), p. 255.

82. "Senators and Defense Leaders Lock Horns Over Budget Buying Power, Base Force Cut", Aviation Week & Space Technology, (Feb 10, 1992), p. 24.

BIBLIOGRAPHY

Army Technology Base Master Plan, Washington, D.C., Government Printing Office, 1990, pp. I-9, I-11, I-23, IV-2, VII-12, and VII-18.

Black, Kent M., "IR&D, An Essential Element of National Defense", National Defense, April, 1988, p. 37.

"Can America Maintain Its Edge", American Legion Magazine, August, 1991, pp. 29 & 55.

Endres, LCDR Joseph and Fremgen, Dr. James, "Non-Mandatory Advanced Agreements", Program Manager, Nov-Dec, 1990, p. 24.

Flamm, Don, "U.S. Aerospace Industry and Key Technologies for the Year 2000", Asian Defense Journal, March 1991, p.76.

Gidley, Teresa R., Gray, Dennis O., and Hetzner, William A., "Cooperative Research and Rising Expectations", Technology in Society, 11, 1989, p. 336.

"Give TQM Its Due Respect", Aviation Week & Space Technology, Dec 9, 1991, p. 7.

Goodman, Glenn W. Jr., "Independent R&D Efforts Suffer in DOD's More Competitive Contract Environment", Armed Forces Journal International, June, 1987, p. 102.

Iverson, J. Richard, "Subtle Forces Undermine National R&D", Armed Forces Journal International, June, 1987, p. 100.

Lopez, Virginia C. and Vadas, David H., The U.S. Aerospace Industry in the 1990s A Global Perspective, Washington, D.C., Aerospace Industries Association of America, Sep, 1991, pp. 9, 14, 17-18, 37, 94-95, 103, 120-122, & 124-125.

National Security Strategy, Washington, D.C., Government Printing Office, August, 1991, p. 30.

Public Law 101-510, "1991 Defense Authorization Act", St. Paul, MN, West Publishing Co., 1991, Title II, Title VIII, and Title XII.

Public Law 102-190, "1992 Defense Authorization Act", St. Paul, MN, West Publishing Co., 1992, Title VIII.

Rustin, Peter, LTC, SDIO, interviewed by LTC Joseph Bergantz, Pentagon, Washington, D.C., 10 A.M., 8 Nov 1991.

Rycroft, Robert W., "Foreign Policy Aspect of Intergovernmental Science and technology", Technology in Society, 12, 2, 1990, pp. 221-222.

"Senators and Defense Leaders Lock Horns Over Budget Buying Power, Base Force Cut", Aviation Week & Space Technology, Feb 10, 1992, p. 24.

Snow, Donald M., "High Technology and National Security: A Preliminary Assessment", Armed Forces and Society, 17, 2, Winter, 1991, p. 255.

Technology for National Security, Washington, D.C., Government Printing Office, 1988, pp. 18, 20-21, 54-55, & 63-64.

Total Quality Management Continuous Improvement Guide, St. Louis, MO, U.S. Army AVSCOM Printing Plant, Oct 1990, p. 10.

U.S. Congress Office of Technology Assessment, Defense Technology Base: Introduction and Overview, Washington, D.C., Government Printing Office, March, 1988, pp. 17-18, 47-49, 51, 59, 61-62, 70, & 80-83.

U.S. Congress Office of Technology Assessment, Holding the Edge, Washington, D.C., Government Printing Office, 1990, p. 8.

U.S. Congress Office of Technology Assessment, Redesigning Defense: Planning the Transition to the Future U.S. Industrial Base, Washington, D.C., Government Printing Office, July, 1991, pp. 4, 50, 52, & 71.

Weidenbaum, Murray, "A Note on R&D Changing National Priorities", Technology in Society, 11, 1989, p. 333.

1991 Joint Military Net Assessment (JMNA), Washington, D.C., U.S. Government Printing Office, March, 1991, p. 5-3.